

By *end*
a non-aqueous composition of an alcohol and at least two inorganic acids[,
wherein a major component of said composition is non-aqueous].

REMARKS

Claims 1-7, 9-11, 13-18, 22-41 and 82-86 are pending in this application.
Claims 1,4, 25 and 82-86 have been amended.

Claim 25 stands rejected under 35 U.S.C. § 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicants regard as the invention. The Office Action asserts that the phrase "selected from the group consisting of ethylene, propylene glycol" is indefinite as an improper use of the Markush language. (Office Action at 3). Claims 25 and 4 have been amended to correct the indefiniteness. Applicant respectfully submits that all pending claims are now in full compliance with 35 U.S.C. § 112, second paragraph.

Claims 1-4, 6, 9, 10, 22-25, 27, 30 and 31 stand rejected under 35 U.S.C. § 102(b) as being anticipated by Mitsubishi Electric Corp. (JP 0048816). The rejection is respectfully traversed.

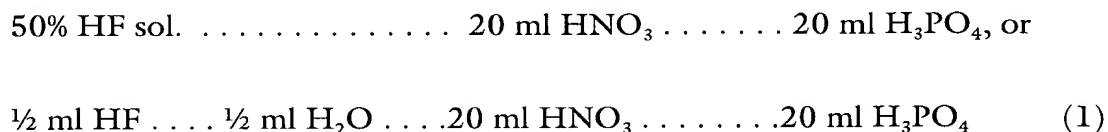
The claimed invention is a non-aqueous etching mixture which consists essentially of an alcohol in combination with at least two inorganic acids. As such, amended independent claim 1 recites a composition for "selectively etching a doped substance" and consisting essentially of "a non-aqueous composition of an alcohol and at least two inorganic acids." Independent claim 22 also recites a "composition for selectively etching doped silicon" consisting essentially of "a non-aqueous composition of an alcohol and at least two inorganic acids." Dependent claims 4 and 25 further recite that the alcohol could be ethylene glycol or propylene glycol, while dependent claims 6 and 27 recite a "C₂-C₆ alcohol." Similarly, dependent claims 9 and 30 recite "hydrofluoric acid,

nitric acid, phosphoric acid, sulfuric acid, boric acid, carbonic acid, perchloric acid and sulfurous acid” as choices for inorganic acids.

Mitsubishi Electric Corp. (JP 0048816) (“Mitsubishi”) does not disclose the limitations of the claimed invention. Mitsubishi discloses an aqueous etchant for silicon, and not a non-aqueous etchant. The aqueous etchant of Mitsubishi includes an acid with viscosity higher than that of water, such as phosphoric acid, or an anionized organic compound with viscosity higher than that of water, such as ethylene glycol or glycerol, in addition to hydrogen fluoride (HF) and nitric acid (HNO₃) (Abstract). According to Mitsubishi, the addition of phosphoric acid, which has a much higher viscosity than that of water, to the aqueous etching solution increases the viscosity of the etching liquid, which in turn is prevented from entering narrow gaps in a silicon semiconductor device (Abstract). In accordance with the data offered by Mitsubishi, an etching solution containing 1 part of 50% HF solution and 40 parts of HNO₃ (by volume) results in a side etching of silicon of about 0.7-0.8 μ m for 1 μ m etching. When, however, 20 parts of HNO₃ are replaced with a substance with viscosity higher than that of water, the side etching of silicon decreases. This way, an etching solution containing 1 part of 50% HF solution, 20 parts of HNO₃ and 20 parts of H₃PO₄ (by volume) gives a side etching of only 0.5 μ m.

The Office Action fails to recognize that the Mitsubishi etchant is not a non-aqueous solution. By definition, a non-aqueous solution is a solution in which the solvent is not water, but may organic (e.g. Et₂O) or inorganic (e.g. NH₃), protonic (e.g. EtOH), or non-protonic (e.g. BrF₃). See D.W.A. Sharp, DICTIONARY OF CHEMISTRY 281 (2d Ed., Penguin Books 1990). On the other hand, an aqueous solution is a water-based solution, or a solution in which the major solvent is water. An aqueous solution may also comprise a non-aqueous solvent, for example an alcohol; however, water must remain the major solvent in order for the solution to be called “aqueous.” Mitsubishi expressly recites an aqueous solution - - “aqueous hydrogen fluoride nitric acid organic compound” and “[E]tchant for silicon with minimal undercutting - of aq. hydrogen fluoride and nitric

acid” - - in the title. According to the data in Mitsubishi, the etchant solution includes (by volume):



In equation (1), the etchant solution has no non-aqueous components and the etching solution is aqueous. As the Office Action repeatedly points out, however, non-aqueous solvents could include “organic liquids such as alcohols, ketones and esters. Commonly used alcohols include ethylene glycol and propylene glycol.” (Office Action at 4, 5, 7 and 8). The replacement,¹ however, of 20 parts of the nitric acid with 20 parts alcohol (a non-aqueous component), for example glycerol [$\text{C}_3\text{H}_5(\text{OH})_3$], does not render Mitsubishi’s etching solution a non-aqueous solution, since water can still remain the major solvent. Accordingly, the limitations of the present invention are not described in Mitsubishi and, thus, the present invention is not anticipated under § 102(b).

Claims 5, 11, 26 and 32 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over Mitsubishi Electric Corp. (JP 0048816) (“Mitsubishi”) as applied to claims 1 and 22. The rejection is respectfully traversed.

The claimed invention teaches an etching mixture which consists essentially of a non-aqueous composition of an alcohol in combination with two inorganic acids. As such, dependent claims 5 and 26 recite that the alcohol is propylene glycol. Further, dependent claims 11 and 32 recite propylene glycol in a composition for etching including nitric acid and hydrofluoric acid. Claims 5 and 11 depend on claim 1, which recites a composition for selectively etching a doped substrate consisting essentially of “a non-aqueous composition

¹ The Office Action mistakenly indicates that the etching liquid in Mitsubishi includes “ethylene glycol or glycerol in addition to 1 part of 50% HF solution and 40 parts of nitric acid by volume.” (Office Action at 3, 6, 7-8 and 9). A careful reading of the Mitsubishi abstract indicates that the alcohol replaces parts of the nitric acid, and it is not added to all 40 parts of the nitric acid. Thus, assuming that an alcohol instead of phosphoric acid would be added to the hydrofluoric acid and the nitric acid, the Mitsubishi etching solution would include 1 part of 50% HF solution, 20 parts of nitric acid and 20 parts of alcohol by volume.

of an alcohol and at least two inorganic acids.” Claims 26 and 32 depend on claim 22, which recites a composition for selectively etching doped silicon consisting essentially of “a non-aqueous composition of an alcohol and at least two inorganic acids.”

The claimed invention is not obvious over Mitsubishi. First, Mitsubishi is silent as to the use of propylene glycol and “at least two inorganic acids,” as independent claims 1 and 22 recite. Second, Mitsubishi does not teach a “non-aqueous” composition, as both independent claims 1 and 22 recite. Mitsubishi expressly recites an aqueous solution (“aqueous hydrogen fluoride nitric acid organic compound” in the title description), while claims 1 and 22 of the invention recite a non-aqueous composition. Third, substituting ethylene glycol with propylene glycol would be of little importance in the present case since the claimed invention recites a non-aqueous composition while, in contrast, Mitsubishi teaches an aqueous solution. Thus, there is no teaching in Mitsubishi for the claimed subject matter.

Claims 7, 28 and 29 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over Mitsubishi Electric Corp. (JP 0048816) (“Mitsubishi”) as applied to claims 1 and 22. The rejection is respectfully traversed.

Dependent claims 7 and 28 recite a C₂-C₆ alcohol selected from the group consisting of ethanol, propanol, isopropanol, iso-butanol, and n-butanol for a composition the major component of which is non-aqueous. Dependent claim 29 further recites “isopropanol” as part of an etching composition.

The claimed invention is not obvious over Mitsubishi. Mitsubishi expressly recites an aqueous solution, while claims 1 and 22 of the invention recite a non-aqueous composition. Further, “replacing ethylene glycol with a conventional alcohol selected from the group consisting of ethanol, propanol, isopropanol, isobutanol, and n-butanol” would not produce the claimed invention, as the Office Action asserts, (Office Action at 5), mainly because the viscosity of the enumerated alcohols varies greatly. For example, 1-propanol has a viscosity of 1.945 mPa s at 25°C, while n-propanol has a viscosity of 2.038

mPa s at 25°C. In contrast, glycerol has a much higher viscosity, of 934 mPa s at 25°C, explained mainly by the addition of the hydroxyl groups. Thus, because Mitsubishi is concerned only with achieving a specific high viscosity for its aqueous etching solution, a person of ordinary skill in the art would not have been motivated to substitute isopropanol, a form of propanol, with glycerol, because isopropanol does not satisfy the viscosity requirement of Mitsubishi. Withdrawal of this rejection is respectfully requested.

Claims 13-18 and 33-38 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over Mitsubishi Electric Corp. (JP 0048816) ("Mitsubishi") as applied to claims 1 and 22. The rejection is respectfully traversed.

The claimed invention teaches an etching mixture which consists essentially of a non-aqueous composition of an alcohol, such as a polyhydric alcohol, in combination with at least two inorganic acids. As such, dependent claims 13 and 33 recite that the ratio of alcohol to a first acid to a second acid is of about 10-50:5-40:1, while dependent claims 15 and 35 further limit such ratio to about 30:20:1. Similarly, dependent claims 16 and 36 recite a ratio of propylene glycol to nitric acid to hydrofluoric acid of about 10-50:5-40:1, while dependent claims 17, 18 and 37, 38, further limit such ratio to about 20-40:10-30:1 and 30:20:1, respectively.

The claimed invention is not obvious over Mitsubishi. First, Mitsubishi is silent about any ratio of hydrogen fluoride to nitric acid. Second, the crux of Mitsubishi is raising the viscosity of the aqueous etching solution, by adding, for example, phosphoric acid instead of half of the nitric acid. For this, Mitsubishi teaches, for example, a mixed liquid of 50% HF solution with HNO₃ 20 parts by volume and H₃PO₄ 20 parts by volume, which improves the viscosity of the etching solution. Even if ethylene glycol or glycerol would replace the 20 parts of HNO₃ in Mitsubishi, equation (1) would give a ratio of alcohol: nitric acid: hydrofluoric acid of about 1:1:(1/40) that is different from the ratio of the claimed invention, which is of about 10:5:1 to about 50:40:1.

Claims 39-41 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over Mitsubishi Electric Corp. (JP 0048816) ("Mitsubishi"). The rejection is respectfully traversed.

The claimed invention recites a non-aqueous etching composition which consists essentially of an alcohol in combination with at least two inorganic acids. As such, independent claim 39 recites "a non-aqueous composition comprising propylene glycol, nitric acid and hydrofluoric acid" in a ratio of 10-50:5-40:1 for selectively etching doped polysilicon to undoped polysilicon. The ratio of propylene glycol to nitric acid to hydrofluoric acid is further defined in claims 40 and 41 as of about 20-40:10-30:1 and 30:20:1, respectively.

The claimed invention is not obvious over Mitsubishi. Mitsubishi is silent about any ratio of hydrogen fluoride to nitric acid or any ratio of propylene glycol to nitric acid to hydrofluoric acid. In addition, Mitsubishi is silent about using propylene glycol, or using propylene glycol at 35°C, on doped and undoped polysilicon. Further, the crux of Mitsubishi is raising the viscosity of the aqueous etching solution, by adding, for example, phosphoric acid instead of half of the nitric acid. For this, Mitsubishi teaches, for example, a mixed liquid of 50% HF solution with HNO₃ 20 parts by volume and H₃PO₄ 20 parts by volume, which improved the viscosity of the etching solution. If 20 parts of HNO₃ in Mitsubishi would be replaced with ethylene glycol or glycerol, equation (1) would give a ratio of alcohol to nitric acid to hydrofluoric acid of about 1:1:(1/40), which is different than the ratio of the claimed invention, that is of about 10:5:1 to about 50:40:1. Withdrawal of this rejection is thus respectfully requested.

Claims 82 and 83 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over Mitsubishi Electric Corp. (JP 0048816) ("Mitsubishi"). The rejection is respectfully traversed.

The claimed invention recites an etching solution which consists essentially of a non-aqueous composition of an alcohol in combination with at least two inorganic acids.

As such, independent claim 82 recites etching of a doped substance by using “a non-aqueous composition of isopropanol and at least two inorganic acids.” Independent claim 83 also recites “a non-aqueous” composition for etching a doped substance and consisting essentially of propylene glycol and at least two inorganic acids.

Mitsubishi relates only to the etching of silicon and only with an aqueous solution with a high viscosity coefficient. Mitsubishi is silent about any doped substance or substrate. Further, Mitsubishi does not teach the use of a non-aqueous solution, but rather the use of an aqueous solution with either an organic or inorganic substance which has high viscosity. Accordingly, there is no teaching or suggestion in Mitsubishi for the claimed subject matter and withdrawal of this rejection is respectfully requested.

Claims 84-86 stand rejected under 35 U.S.C. § 102 as being anticipated by Mitsubishi Electric Corp. (JP 0048816) (“Mitsubishi”). The rejection is respectfully traversed.

The claimed invention teaches an etching liquid which consists essentially of a non-aqueous composition of an alcohol in combination with at least two inorganic acids. As such, independent claim 84 recites the etching of “doped amorphous, doped pseudo-crystalline or doped polycrystalline silicon.” Independent claim 85 recites the etching of doped germanium, whereas independent claim 86 recites the etching of gallium arsenide with the non-aqueous etching mixture.

Mitsubishi does not disclose the limitations of claims 84-86. Mitsubishi discloses an aqueous composition for etching only silicon, which includes an acid with viscosity higher than that of water, such as phosphoric acid, or an anionized organic compound with viscosity higher than that of water, such as ethylene glycol or glycerol, in addition to hydrogen fluoride (HF) and nitric acid (HNO₃) (Abstract). Mitsubishi does not disclose, therefore, “a non-aqueous composition,” or “a composition for selectively etching a doped amorphous, doped pseudo-crystalline or doped polycrystalline silicon, as independent claim 84 recites, or for etching doped germanium, as independent claim 85

recites, or for etching gallium arsenide, as independent claim 86 recites. Accordingly, the limitations of the present invention are not described in Mitsubishi and the present invention is not anticipated under § 102(b).

In view of the above, each of the presently pending claims in this application is believed to be in immediate condition for allowance. Accordingly, the Examiner is respectfully requested to withdraw the outstanding rejection of the claims and to pass this application to issue.

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Respectfully submitted,

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